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The National Cancer Institute's Emergency Virus Isolation Facility: A Case Study for Use in Developing A Methodology of Post-Occupancy Evaluation

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Washington, D.C. 20234

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Final Report

Prepared for
Engineering Design Branch
Division of Engineering Services
National Institutes of Health
Bethesda, Md. 20852

Corrections to NBSIR 77-1402

p. 8 Last paragraph should read:

"Finally, once a decision is made concerning the performance to be measured, a decision is needed concerning how the measurements are to be made -- the research method used. It is a step by step..."

p. 30 Delete last three lines (they are repeated on page 31).

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TABLE OF CONTENTS

	Page Number
ACKNOWLEDGEMENTS	iii
1.0 INTRODUCTION	1
2.0 BUILDING EVALUATION - GENERAL	3
2.1 PAST STUDIES OF EVALUATION	4
3.0 A FRAMEWORK FOR EVALUATION	7
4.0 THE EVALUATION APPROACH	10
5.0 THE EVALUATION FOCUS	13
5.1 THE PROGRAMMING PROCESS	13
5.2 OPERATION OF THE BUILDING	14
6.0 THE EVALUATION METHOD	16
6.1 HISTORICAL ANALYSIS OF THE DOCUMENTATION	16
6.2 INTERVIEW WITH THE ARCHITECT	16
6.3 INTERVIEW WITH THE MANAGERS AND OPERATORS	17
6.4 CASUAL OBSERVATIONS	17
7.0 FINDINGS	18
7.1 THE PROGRAMMING PROCESS	18
7.1.1 HISTORICAL ANALYSIS	18
7.1.2 INTERVIEW WITH THE ARCHITECT	20
7.1.3 INTERVIEW WITH THE MANAGERS AND OPERATORS	21
7.2 OPERATION OF THE BUILDING	21
7.2.1 HISTORICAL ANALYSIS	22
7.2.2 INTERVIEW WITH THE ARCHITECT	22
7.2.3 INTERVIEW WITH THE MANAGERS AND OPERATORS	25
7.3 SUMMARY	26

Page Number

8.0 CONCLUSIONS. 28

8.1 ASSUMPTIONS 28

8.2 PLANNING CONSTRAINTS. 30

8.3 DESIGN CONSTRAINTS. 30

8.4 INFORMATION CONSTRAINTS 30

8.5 CONCLUSIONS OF BUILDING 41 STAFF. 31

9.0 RECOMMENDATIONS. 32

10.0 REFERENCES 36

APPENDIX A 37

APPENDIX B 56

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1.0 INTRODUCTION

This report represents an early attempt to develop a generalized model for building evaluation through the analysis of the pre-design programming process and the post-construction operation management of a specific building. The report results from a concern for how buildings meet community and user needs. The National Endowment for the Arts responded to the concern by funding the AIA/Research Corporation (AIA/RC) to plan a post occupancy evaluation project.

After the initial planning, four federal agencies expressed interest in participating in the project, the National Institutes of Health (NIH), the General Services Administration (GSA), the Department of Housing and Urban Development (HUD), and the Army Corps of Engineers (CORPS).

The participation of the above agencies with diverse missions, but common environmental problems, provided the basis for defining the project goals. The long range goal of the project is to provide a mechanism for evaluating buildings as a part of the Federal design process. The immediate goal is to provide the beginning of a methodology for post-occupancy evaluation by examining the process used to design and construct several buildings.

The National Bureau of Standards (NBS) was brought into the project by the AIA/RC to carry out part of the overall evaluation task. Following meetings between NBS and AIA/RC, it was decided that NBS would be the primary evaluator for the NIH and GSA buildings. (The HUD and Army buildings were examined by a private contractor.)

The evaluation reported herein represents the post occupancy evaluation of the National Cancer Institute's Emergency Virus Isolation Facility (Building 41). The facility is a laboratory building designed to provide an experimental research environment capable of handling all levels of hazardous work related to virus-cancer research. The three story, 205 room, 41,350 square feet structure was designed to accommodate a staff of approximately 120 people comprised of scientists, technicians, and animal handlers [1].

The body of the report contains; discussion of building evaluation in general; the approach and method used; the findings resulting from the method; conclusions drawn from the findings; and recommendations to NIH. It is intended that the evaluation approach and evaluation method used in this case study serve as input for developing a methodology for post-occupancy evaluation that will be a compatible part of the federal design process.

2.0 BUILDING EVALUATION - GENERAL

Building evaluation is the process by which some aspect, event, or relationship over the life of the building (from planning to demolition) is compared to a normative standard or set of criteria for the purpose of determining worth or quality. Evaluation findings are of primary value to those individuals or groups responsible for the design, management, or regulation of buildings. In essence, the findings consist of information or data necessary for effective decision making.

Because decision making goes on throughout the life of a building, evaluation can include one or all of a full sequence of events starting with the decision to build a new building; the planning and design phase; the construction; and the routine operation of the building [2].

Evaluative analysis differs from traditional scientific analysis in its emphasis upon producing value judgements that can be used for corrective action in the conduct of some set of organized man-building activities. An evaluation is relevant only when it results in the implementation of its findings: either in terms of correction and retrofitting or as input to similar processes to be undertaken by others. Regardless of its use, evaluation can

achieve its potential only if the basis on which decisions were made can be traced [2].

2.1 PAST STUDIES OF EVALUATION

Most of the important evaluation efforts over the past two decades have been analyses of residential building types and their immediate surroundings [3] [4] [5] [6]. Many of the early evaluation efforts resulted from the "social consciousness movement" and programs of the sixties. This movement, and the federal programs which were developed in response to it, were aimed at bringing minority groups into the mainstreams of American life. During that time, housing received substantial Federal funding, with much of the money contingent on maximum feasible participation in the planning process by the occupants (users). The user participation requirement resulted in efforts by designers and others to determine the needs of housing users.

Research concerned with user satisfaction in varied housing environments became one of the established processes for determining user needs. User satisfaction studies soon became synonymous with housing evaluation investigations and eventually became the focus of building evaluation investigations in general. The dilemma resulting from this evolved association is aptly stated [7] in the following quotation from an evaluation of a university laboratory building:

". . . the common assumption in today's evaluation studies is that the user's satisfaction is to be taken as the standard against which buildings are measured. We would certainly agree that it is time the design professions took more notice of the needs of the users, but it is naive to assume that they are the only people whose satisfaction

matters. There are many people who do not actually work inside a building whose attitude or professional duties will influence the physical conditions faced by the users. In many institutions the board of trustees approves appropriations for new buildings; its opinions may carry some weight. The financial vice president of a university expects a building to meet certain criteria, which will not necessarily be compatible with the users' criteria. So will the insurance agent, the fire marshal, the head of the campus security staff, the chief of the university maintenance staff, the head of the institution that lends funds, the members of the community who must look at the building on their way to work. Now it might be argued that all these criteria are secondary; what really counts is the user's satisfaction, and his demands should take precedence. But the matter is not so simple. One may agree, for example, that a scientific lab should not be built to suit the security staff, but if the building is so difficult to police that expensive equipment keeps disappearing, it is the users who will suffer. If a laboratory that pleases its users is so expensive that money is drained away from other parts of the university, how are competing values to be reconciled? Obviously, if the viewpoints conflict, any choice be clear that the definition of a satisfactory building cannot depend on an examination of the users alone. In any case, decisions made by other groups will influence the way the occupants can use their building.

The other aspect of the problem is deciding which users are to be considered. Even the people who actually work inside the building have different expectations, and their varying demands may conflict. The head of a department evaluates his building from a point of view that may diverge from that of other senior professors. Judging from our experience, he will be more inclined to worry about changes in types of experiments and therefore in room use or about facilities for group activities or storage for shared materials. His viewpoint will undoubtedly diverge from the viewpoint held by junior professionals, technical staff, secretaries, and so on. How are these divergent viewpoints to be reconciled? Obviously, if the viewpoints conflict, any choice among them involves a tradeoff, and an evaluation study ought at least to be able to say that although scientists found this laboratory highly successful on these grounds, the same characteristics displeased the technicians for the following reasons."

Fields, et. al. [2] discuss evaluation in terms of what to evaluate. According to the authors, there are four different bases for evaluating buildings. The first is the original purpose and/or any changed

purpose for which a building was designed. The second is the process (the development of an architectural program and the organization of resources for its accomplishment) by which a building is built. The third is the building itself. This would include (1) physical performance of the building parts, (2) the effect of their performance on human performance, (3) the effect of human performance on the building parts, and (4) human performance as related to the purposes or goals. The fourth is the operation and maintenance of buildings and would include administration, personnel, upkeep, financing, etc. [2].

The past studies point out the importance of defining both the nature and the extent of the evaluation. However, there remains the need for a convenient means by which an evaluation effort can be defined. One way would be a method for structuring evaluation around the characteristics, qualities, etc., that are essential to its performance.

3.0 A FRAMEWORK FOR EVALUATION

In order to develop an effective evaluation methodology, a conceptual framework is needed. Figure 1 depicts a framework that is recommended, and was used in this project. It is not only useful in helping to describe the scope of an evaluation, but also in defining informational requirements for making particular decisions. For example, if decisions concerning a building subsystem are required, information is necessary concerning the various categories under the "building in use" with respect to the subsystem.

Figure 1

THE THING BEING EVALUATED OR EVALUATION WITH RESPECT TO / EVALUATION WITH RESPECT TO OR THE THING BEING EVALUATED	ARCHITECTURAL PROCESS			BUILDING IN USE					
	BUILDING PROGRAMMING	BUILDING DESIGN	BUILDING CONSTRUCTION	USER HEALTH	USER SAFETY	USER COMFORT	USER ACTIVITY SUPPORT	USER MANAGEMENT	BUILDING OPERATION
BUILDING SUBSYSTEMS									
USER ACTIVITIES									
USER-BUILDING RELATIONSHIPS									

As was mentioned earlier [2], there are four generic categories of issues or conflicts that can serve as the focus of an evaluation. The framework shown in Figure 1 expands these four categories in a 27 intercept matrix. Each intercept defines two possible issues for evaluation; therefore, 54 foci for evaluation are obtained. For example, a building subsystem such as the plumbing can be evaluated in terms of its maintenance cost in the overall building operation. Alternatively, building operation can be evaluated in terms of plumbing maintenance costs. While plumbing maintenance cost is the performance criteria in both instances, the subjective contents of the evaluations are completely different.

Once the focus of the evaluation is determined, the next important issue to be addressed is the identification of the particular performance for which measurements will be made. For example, the building can be evaluated in terms of its performance with respect to reliability of parts, serviceability, economics of operation, and/or any of numerous other characteristics. In much the same way, the requirements of users can be evaluated in terms of efficiency of task performance, aesthetic satisfaction, etc. Overall user-building performance can be determined in terms of fire safety, accident safety, and the consequence of any of the activities being carried out (or not carried out) within the building.

Finally, once a decision is made concerning the performance to be measured, a decision is needed concerning how the measurements are

planning that is critical to the success of the evaluation effort. The systematic and logical approach makes evaluation analogous to research in general.

4.0 EVALUATIVE APPROACH

The long term goal of the research program under which the current project was undertaken, is the development of a mechanism to evaluate buildings from the standpoint of user requirements. Consequently, the focus of attention was one which would apply to the design of all buildings -- the programming process. By understanding how the programming process affects the overall effectiveness of buildings (in terms of responsiveness to the activities of users) significant progress is possible in two areas.

1. Determining where, when and how in the design process, the activities of users are influenced.

2. Developing a framework for identifying and developing information from users which can be effectively applied in design.

The building being evaluated in the present study (NIH-Building 41) was evaluated by comparing its architectural programming and planning activities with a generally accepted format (normative standard) for programming and planning (see Appendix A). The reason for the comparative form of evaluation was to discover discrepancies between the actual and normative programming formats and see if these discrepancies could be correlated with problems found in the current operation of the building.

This type of evaluation is predicated on the assumption that the ability of the building to support all the human and/or machine activities and

processes that it houses is directly related to either the presence or absence of information specifying its performance and the quality of such information when present. The information discussed is that included in an architectural or building program or any other method used for transmitting building performance requirements, criteria and directives to the designer.

Two levels of analysis were performed, the first one was concerned with the presence or absence of a category of information. The second more detailed, analysis was performed to determine the usefulness and completeness of user-related information, when it was dealt with in the program.

If a standard program (see Appendix A) can be defined, any particular program can be compared with it to determine its comprehensiveness. It can be assumed that those categories which have no information were either overlooked or not considered to be significant. It can then be hypothesized that building performance with respect to the missing category will probably be deficient in some way. This hypothesis can then be tested with respect to the operation of the building.

However, even when a general topic (information category) has been covered in a program, little assurance exists that the information needed by the architect will be made available in a useful form.

Consequently, the next research concern was to evaluate the quality and form of the information employed in the program, to determine

whether they could be later related to the problems found in the building. If this connection could be made, then suggestions could be made for improved procedures to develop user information.

5.0 EVALUATIVE FOCUS

The evaluation consisted of two interrelated activities -- one focusing on the programming process, and the other on the operation of the building.

5.1 THE PROGRAMMING PROCESS

The activities performed initially in this evaluation were directed toward determining the programming process employed for Building 41 and comparing this process with a "standard program" mentioned earlier. The informational categories appearing in the standard program were then compared with those same categories in the actual Program of Requirements (POR).

The design process used for Building 41 was then examined to identify user-related issues -- that is, to establish relationships between design activities (decisions) and building user requirements.

Among the issues addressed were:

Information Issues

- Sources of information (e.g., people, reference works)
- Means of developing information (e.g., who asks questions, how?)
- Quantities and forms of information needed
- Identification of necessary user data

Design Process Issues

- Location in the process where user data is needed
- Mechanisms necessary to effectively insert user data into the process
- Modification of the design process (if needed) to avoid and/or identify and solve user problems
- Development of an effective feedback loop into the process -- using operational data.

5.2 OPERATION OF THE BUILDING

The next task was to analyze the building from the standpoint of occupant activities to identify user problems. The problems were then examined to determine how they were related to the information developed in the design program. Examples of the issues explored are provided below:

The original design assumptions

- Building 41 will be used primarily in a maximum safety mode (high risk)
- Safety problems can be solved by proper building and engineering design
- Safety procedures will not adversely effect user activities
- The research to be conducted in the building is challenging and has a reasonable expectation of being very important

- The functions to be performed by the building are not likely to be changed

User related problems

- User safety in terms of biological hazards to researchers and other users of the building
- User activity support in terms of sound and noise, accessibility, and dimensional requirements
- User management in terms of required procedures and space allocation
- Building operation in terms of subsystem reliability, subsystem maintainability, and subsystem durability

The findings from the evaluation will address the issues of the programming process and assumptions and problems related to the building operation.

6.0 EVALUATION METHOD

The evaluation method consisted of

(a) An historical analysis of the documentation of the architectural programming and planning phase of the building;

(b) Interviews with the individuals responsible for the design of the building;

(c) Interviews with the individuals responsible for managing the operation of the building; and

(d) Informal observations in and around the building.

6.1 HISTORICAL ANALYSIS OF DOCUMENTATION

The historical analysis of the programming documentation included examination of; correspondence prior to the program; the program of requirements produced by the programming consultants; and the diagrammatic report and meeting notes of the architects. These documents are all in the Building 41 file at the Engineering Design Branch, NIH.

6.2 INTERVIEW WITH THE ARCHITECT

A one day interview with the building architects was held at their offices. The project leader and principal-in-charge reported on the architectural phase of the project. The questions asked by the project interviewers concerned the usefulness of the program document in making design decisions. The remainder of the interview was a free flowing discussion of the architects' memories of the project.

Another day was spent walking through the building with a member of the architectural team responsible for its design. Neither the discussion nor the route through the building was formally structured, but rather, an informal observation and walk through was employed. In general, the discussion related to the planning and design process for the building and the current in-use operation of the building as it was observed.

6.3 INTERVIEW WITH MANAGERS AND OPERATORS

The interviews with the managers and operators of the building included meetings with: the individuals responsible for safety policy and practices of the professional staff; the administrator in charge of the support personnel; and the operator and monitor of the building systems. Each interview lasted about a half an hour. Questions covered the interviewee's major responsibilities and the ways, if any, the building conflicted with them. In addition, the interviewee was asked how the building could better serve his/her needs and if this information was elicited at the architectural programming phase.

6.4 CASUAL OBSERVATIONS

Walks through and around the building were made on two separate occasions. The physical characteristics of the building and the number and type of staff were observed. Photographs were taken during these visits and are shown in Appendix B.

7.0 FINDINGS

7.1 THE PROGRAMMING PROCESS

The standard information categories as developed in the Standard Program (Appendix A) were compared with two documents. The first was the "Program of Requirements (POR) for Emergency Virus Isolation Facility of the National Cancer Institute", prepared by Pitman-Moore Division of the Dow Chemical Company, the programming consultants for the project. The second document was the "Diagrammatic Report for Emergency Isolation Virus Facility of the National Cancer Institute." It was prepared by Sanders and Thomas, Inc. the architects-engineers of the building.

7.1.1 Historical Analysis

The program of requirements contained the information in Table 1.

TABLE 1

1	Introduction	Statements concerning the need for and objectives of the facility.
2	Description of	A description of the programs or major activities to be housed.
3	Space Directive	A listing of square footages required by the number of rooms, types of rooms, with respect to each of the programs or major activities.
4	Design Criteria	General qualitative statements concerning the characteristics of the building and a more specific narrative dealing with the requirements of the building parts.
5	Appendix	A site location plan and a glossary of terms.

The Diagrammatic Report consisted of the information in Table 2.

TABLE 2

1	Scope of Project	What the project would consist of
2	Project Background	Relationship to the POR
3	Environmental Impact	Relocation of personnel at NIH
4	Site Approval	Data approved
5	Siting Arrangement	Building siting, parking, future expansion, service facilities, and roads are included
6	Design Criteria	General, architectural, structural, mechanical, plumbing, electrical, and safety criteria are covered
7	Materials, Equipment, and Systems	Areas included are general, architectural, structural, mechanical, plumbing, and electrical
8	Funding and Control Estimate	Budget considerations
9	Schedule	Completion dates
10	Appendix	Minutes and correspondence from conferences and field trips.

Comparisons with the Standard revealed six missing information categories. The six missing categories were: 1) the organization structure and subgoals of the operations and processes housed; 2) requirements or criteria for furnishings and equipment; 3) information on occupant flow; 4) requirements for information flow; 5) particular requirements concerning spatial configurations and relationships; and 6) how the facility will be managed or operated. Two other categories had partially missing information: 1) requirements or criteria for the acoustical environment; and 2) requirements based on the climatic conditions of the Bethesda, Maryland area.

7.1.2 Interview with the Architect

According to the architect, the POR did not provide the information necessary to start the design of the building. The POR indicated what the client wanted, but, not in a form useful to the architect. For example, the POR described laboratory procedures, but not in design or building performance terms. In other instances, detailed information was provided and was felt to be too restrictive. Categories where information was considered insufficient or restrictive are:

*The activities to be performed in given spaces

*Configuration of equipment in space

*How furnishings should be placed in spaces

*Relationships of activities, spaces, equipment, people to one another.

Instead of serving the intended purpose, the POR was used as a starting point for developing the Diagrammatic Report. The Report (together with accompanying illustrations) represented a preliminary design for the facility, and specific criteria for design.

7.1.3 Interview With the Managers and Operators

The discussions with the managers and operators of the building resulted in findings that were primarily concerned with the lack of opportunity for managers and operators to participate effectively in the programming process. It was felt that the recommendations of managers and operators should not only be elicited, but to also be given serious consideration in the renovation of existing buildings and the planning of new ones.

They also felt that there should be a better way of predicting or planning for the continual changing and expanding needs for laboratory equipment. In addition, managers and operators believed that they should have safety training or instruction concerning biohazards research.

7.2 OPERATION OF THE BUILDING

Building 41 was planned as a center for research devoted primarily to searching for a link between viruses and human cancer. When the building was being designed, this approach appeared to be a highly promising one which had to be pursued under conditions which minimized safety hazards to the researchers, and the community at large. Safety was the overriding concern in the anticipated operation of the building.

7.2.1 Historical Analysis

The two major goals specified for the building by the programmers were:

*A major emphasis on safety from biohazards while employing the best current practice in fire and safety protection in the building and research procedures.

*Continuing research and development to improve the methods for control and containment of biohazards, and to insure continued updating of the facility.

The primary objective of the building was apparently met -- the safety design was appropriate, as evidenced by the lack of problems encountered by the staff and the surrounding community since the building has been in operation. However, while the building is believed to be capable of housing research at all risk levels (minimal, low, moderate, high), it has never had to perform at the highest level. Therefore, safety at the highest risk level is not a proven fact, but rather conjecture based on professional judgment. Nevertheless, the building has proven to be an effective model for the design of other laboratories, where comparable types of research is conducted.

7.2.2 Interview With the Architect

While the architect has no responsibility for the day-to-day operation of the building, a walk through the building was helpful in identifying

operational characteristics having a relationship to the building design. The most salient issues addressed are described in tabular form in Table 3.

TABLE 3

Issue	Response
Laboratory Equipment	There was a good deal of equipment stored in corridors and in niches along corridors. The architect stated that he neither selected equipment nor sized and designed the laboratories. He felt that some of these additional and changing equipment needs could have been anticipated and designed for.
Laboratory Design	The laboratories were designed on a 5 foot and 10 foot modules with multiple mechanical service locations. It was not evident that the flexibility designed into the spaces had ever been taken advantage of. The spaces and the multiple service locations appeared to be the same as at the time that they were installed. New laboratory spaces are being added to the building. The architects response to them was that they appear more attractive because of the light colors on the walls and furniture. (Another architect is designing the new spaces)
Surfaces	The many cracks in the concrete floors could not be explained by the architect. He felt that an adequate number of expansion joints had been designed. In any event, there had never been any feedback from the client concerning this problem. Based on experience with previous laboratory building design, the architects specified sealants and epoxy paint that was expected to be very reliable. From all indications, both the sealed joints and the epoxy surfaces have held up well.
Maintenance	According to the architect, the dirt and trash observed in the light fixtures in the labs not only reduce the light level but also indicate a less-than-designed-for maintenance program. (The light fixtures are sealed from the lab side and must be maintained from the mechanical floor above) Emergency shower floor drains appeared dirty and not well maintained. The architect pointed out that emergency shower floor drains are no longer being installed in laboratory buildings because they are culture producing beds.
Ventilation System	The selection and specification of a particular venturi valve in the ventilation system along with possible leaks is believed to have been the cause of excessive noise in the lab spaces. It was observed that all of the original venturi valves are systematically being replaced.
Waste Treatment System	The design for the bio-waste treatment system remains current with similar systems being designed today.
Landscaping	The architects developed a large landscaping program for the building. It was observed that while the program was implemented, the planting is not being well maintained.

7.2.3 Interview With the Managers and Operators

Two types of issues were evident from the discussion with those managing and operating the building. One issue area could be termed design related, while the other appears to be associated with procedural and administrative factors.

7.2.3.1 Administrative/Procedural Problems

Various problems were identified which may be attributed to the general administration of the building. There was a lack of agreement as to who is responsible for managing the building, and it was pointed out that research space assignments are made in accordance with program needs--which are not always synonymous with levels of risk. For example, high risk laboratory areas do not necessarily house high risk activities.

Problems attributable to procedures were focused on the frequent long delays associated with equipment installation and/or repair--impairing research effectiveness. In addition, the requirement to shower and change clothes when leaving and entering work areas was often perceived as unnecessary by many staff members (This procedure has since been modified).

7.2.3.2 Design-Related Problems

A variety of problems were identified which may be attributable to the features, location and usage of the building. The problems were not related to health risks, but rather were focused on the characteristics and quality of the physical surroundings which in turn led to feelings of isolation on the one hand, and discomfort on the other.

With respect to space, general cleaning in the laboratory suites is hampered by excesses of equipment in the laboratories and corridors. Also, insufficient locker space was set aside for a capacity work force to store clothing and other personal articles for clothing changes necessary when entering and leaving the high risk areas.

7.3 SUMMARY

Occupants of Building 41 commonly feel isolated from their colleagues in the same building, and more so from activities going on elsewhere on the NIH site.

With respect to those who share occupancy in the building, each laboratory (for safety purposes) functions as a virtual isolation chamber. The building design makes it very difficult for one researcher to casually visit a colleague. The building does not contain many common spaces which might be used as a place to meet and discuss matters of mutual concern. A "sense of community" within the building therefore does not exist. Furthermore, the building itself is located away from the other primary research facilities of NIH. As a result, it is difficult for occupants of Building 41 to attend seminars, lectures and other activities frequently occurring at the NIH complex.

The design of the building for maximum safety resulted in a very "hard" environment -- acoustically and visually. The hard surfaces, desirable for cleaning, resulted in major noise problems. One

factor contributing to the undesirable noise situation (also a safety factor) was the number of hourly air changes -- 48. As a result, the working environment consisted of high levels of fan, air conditioning and other equipment noise reflected throughout the building by the hard surfaces. The interior of the building had many of the qualities of a reverberation room (e.g., the sound decayed quite slowly) thereby creating a very unsatisfactory working space. The grey and green institutional colors applied to the hard glossy surfaces made the building seem cold and sterile. The collection of debris in the sealed light fixtures in the laboratories, and the aging and wear of equipment and furniture contribute the image of an undesirable environment.

8.0 CONCLUSIONS

Based on the analysis of the programming documents, the greatest concern addressed was the safety to researchers and the community at large. The building is considered to be highly successful with respect to safety from biohazards. On the other hand the problems with the building can be traced to basic assumptions, planning constraints, design constraints, and the absence of important information in the program.

The programs of research conducted in Building 41, and the safety precautions followed, differ considerably from those envisaged when the building was designed. A number of factors have influenced this outcome.

8.1 ASSUMPTIONS

-The primary activity conducted in the building would be research on a possible link between viruses and human cancer -- a high risk level program.

-While viral research played an important role during the early years of the facility, more recently other programs have been housed in Building 41. Later programs did not pose equipment risks -- nor were their potential payoffs as exciting.

-The safety problem is one amendable to hardware solutions primarily - with procedural factors playing a secondary role.

-The discussion with NIH operations personnel indicated that "the proficiency of the individual" in following appropriate procedures was the key to safety. Following in priority order was the primary containment equipment (laboratory equipment) -- with the characteristics of the building playing largely a backup and "insurance" function. They emphasized the need for formal courses and training aids as a critical safety measure -- especially for researchers newly introduced to performing hazardous research. Carelessness was a primary problem to be overcome.

While the building (and operating systems) met the safety design goals for high risk research it is unclear whether lower risk research (levels 1, 2, 3) is optimally performed in the building as it is now used. That is, if it were known earlier that many spaces in the facility would house research at a variety of risk levels, would the same design (building, equipment and subsystems) have been employed?

-Once the safety of the building (and its occupants) is assured -- no major problems are anticipated which would imperil the success of a research program.

-There have been problems associated with the environmental quality provided by the building -- and the safety procedures instituted. We noted earlier that there were complaints due to the noise and illumination characteristics of the building, the perceived isolation of the occupants and the procedures that had to be followed to ensure safety.

8.2 PLANNING CONSTRAINTS

Two factors were of predominant importance in the design of the building -- time and budget. While all building design is responsive to these factors, they were of particular importance in the present instance. The architect had only 16 weeks to prepare the required construction documents for a building with requirements that were unique in many ways. Furthermore, the budget was the continual yardstick employed to evaluate the extent of the work.

8.3 DESIGN CONSTRAINTS

The architect's freedom to plan and design the building was restricted in several ways. Consultants supplied the design of individual laboratories, and the configuration of equipment. The client selected the furniture, equipment, and the site upon which the building was to be constructed. The Program of Requirements (POR) was presented to the architects by the National Cancer Institute as the formal document representing their needs and requirements in a new laboratory building.

8.4 INFORMATION CONSTRAINTS

The problems identified as "man/building" and human problems (e.g., sense of isolation) suggest that the procedures used to develop the initial design information should be examined. For example, user requirements were identified by researchers who were at the time working in an entirely different environment from the one they would be occupying

initial design information should be examined. For example, user requirements were identified by researchers who were at the time working in an entirely different environment from the one they would be occupying later. Their primary goal was to ensure that the planned research could be performed safely. There was no reason for them to anticipate that the new environment could be a relatively "hostile" one. On the other hand, if the environment being designed were examined by someone with experience with isolated facilities (e.g., radar stations in Alaska; underground weapons and communications centers), the problems later encountered might have been anticipated. That is, a careful examination of the working space and procedural constraints placed on those working in the building would have highlighted the isolation problem and even the psychophysical ones (noise and illumination).

8.5 CONCLUSIONS OF BUILDING 41 STAFF

Not surprisingly, the conclusions of the operators and managers interviewed, focused on operational and management issues -- not design factors. They are summarized below:

*There should be a better way of predicting or anticipating equipment needs in laboratory buildings.

*The building operators and maintainers should be more familiar with the research projects in the building to anticipate building system or subsystem impacts.

*The building operators and maintainers should have safety training or knowledge concerning biohazards research.

9.0 RECOMMENDATIONS

Information concerning organization structure and facility operation was commonly touched on during interviews, yet, was not given sufficient attention in the design program. The lack of acoustical criteria for the research environment has evidently resulted in costly renovations. Similarly, the absence of criteria for furnishings, equipment, and laboratory room geometry seems to have resulted in equipment crowding and continual laboratory rearranging. The topics of occupant flow, information flow, and climatic conditions were not touched on in the interviews.

It is clear that certain of the missing information categories relate to problem areas identified in the interviews. Other problem areas related to categories where information was available but inadequate. The conclusion drawn is that missing programmatic information is an important issue in building design or evaluation, and equally important is the quality of the information present. The interview with the architects pointed out that merely stating what is expected or required in a building will not guarantee an adequate solution in the final construction. For information to have an impact on a design of a building, it must both be present, and in a form that can be readily incorporated in the design process. Perhaps a key issue is the need to develop a process which will enable clients, users and architects to be more explicit in stating (and meeting) user requirements.

The two most salient points made during the walk-through of the building with the architect were; (1) the flexibility that the architect designed for is not in evidence of having been needed; and (2) building maintenance played a leading role in certain design decisions. This suggests that; (1) a more detailed understanding of the use of the term "flexible space" is needed by the various participants in the planning process; and (2) unless there is an agreement on the part of both designers and building operators as to the extent of maintenance or any other issue in an organizations' procedures, faulty or wrong decisions can be made. Therefore, both the quantity and quality of the programatic information are essential to design decisions.

Because numerous buildings constitute the large volumes of space required to house the activities of NIH it is important that these buildings are both designed and managed in such a way as to most effectively support their enclosed operations. While it is not currently possible to accurately correlate workdays lost, task efficiency, etc. with building design, it has been well established that buildings do affect the activities of their occupants.

In order that new and existing buildings be designed and operated to respond to the activities housed, criteria must be established in terms of both human habitability and building performance. The effort of this evaluation has been to identify those categories in which design criteria are required and to use them as the basis of analysis of a building in operation.

The evaluative process used for the Building 41 could easily be expanded and developed as a general building evaluation methodology. In other words, the process of evaluation can be standardized even though the performance being judged will vary with respect to design criteria. Therefore, it is recommended that work toward the development of a general methodology be continued.

In addition, consideration of an evaluation methodology as part of a total project analysis package is recommended. Because evaluation is an integral part of a process that includes feasibility analysis, economic analysis, site analysis, and operation and building programming, it must be related to all parts. The objective of a project analysis package would be to develop a process model for describing the relationships between parts and the resources and constraints of the context.

To meet the objective the following approaches should be taken:

1. A continuation of the interviews with user groups in Building 41 to provide guidelines for the quality of the information necessary in program documents.

2. Exploration of approaches to improve the interaction between architects, users and clients that will result in identifying all information necessary to ensure a responsiveness to the needs of all building users.

3. Development of a building programming approach at NIH that links user requirements to all phases of the architectural process over time.

4. Development of a feedback mechanism so that information concerning building operation can be incorporated in new building design and the operation of existing buildings.

These approaches make it possible to systematically progress toward the objective. All four comprise a total research project, however, any one can be developed independent of the others.

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APPENDIX A

Defining the Standard Program

As a process, architectural programming is the gathering, analyzing, evaluating, organizing, and presenting of information necessary for building design [1]. The program, as a product, is a device for transmitting specific types and categories of information, primarily to the building designer. The program for a specific building can be evaluated with respect to the comprehensiveness of its information content if a standard for information comprehensiveness can be defined.

In order to begin to define the standard, a review of the programming literature was undertaken. From the review, it was determined that the publications on the subject are either general or specific with respect to a building type. Those that are general for all buildings assume that, at a certain level of categorizing, the required information classes are the same regardless of what activity the building houses. The literature dealing with specific building types tends to be detailed in the area of the functions of activity housed.

Obviously, the two approaches are evidence of the differing concerns and audiences involved. However, both tend to be similar at certain levels of information categories and the only real difference is in terms of the level being discussed. The two primary information categories common to all of the literature are; (1) information concerning the operations and processes housed; and (2) information concerning the building or its parts. These primary categories are supported by

secondary categories dealing with either the context or the constraints by which they are to be considered.

For illustrative purposes, several examples of program information content are presented in Figures 1A to 8A. Additional examples may be found in the bibliographic citations. It is important to mention that the specific building type examples are for hospitals or health facilities rather than research laboratories. The literature search did not reveal publications dealing specifically with programming or planning research laboratory buildings. Instead, they occurred as spaces within either medical or education buildings. The literature on medical and health facilities related to the operations in Building 41 and was therefore selected for consideration.

On the following three pages, the two general information categories mentioned earlier and the programming literature reviewed are synthesized into first level or general information categories that represent a standard program format.

Additional levels of breakdown of each of the categories gives increasingly more specificity to the information. However, since the interviews and observations are designed to elicit only general information, it was not deemed necessary to reduce the categories any further.

The information groupings as given represent a standard for the types of information necessary in the design of either a laboratory or health service building.

INFORMATION CATEGORIES REPRESENTING A STANDARD PROGRAM FORMAT

1.0 INFORMATION CONCERNING THE OPERATIONS AND PROCESSES HOUSED.

1.1 Organizational goals

1.2 Occupant categories

1.3 Occupant activities

1.4 Machine operations

2.0 INFORMATION CONCERNING THE CONTEXT OR CONSTRAINTS OF THE OPERATIONS AND PROCESSES

2.1 Organizational structure and subgoals

2.2 Role of occupant categories within organization structure

2.3 Types of activities performed by occupant categories

2.4 Numbers of occupants per category

2.5 Nature of various occupant activities

2.6 Role of the activities within the organization structure

2.7 Number and types of people per activity

2.8 Air, radiant, and sonic environment

2.9 Furnishings and equipment

2.10 Power and community requirements

2.11 Spatial requirements and relationships

2.12 Occupant flow

2.13 Material and equipment flow

2.14 Information flow

2.15 Similar operation and process critical issues

2.16 Convenience, health, and/or safety requirements or standards

2.17 Codes and land use restrictions

2.18 Area and regional integration requirements

2.19 Growth and change requirements

3.0 INFORMATION CONCERNING THE BUILDING OR ITS PARTS

3.1 Total Building

3.2 Structure

3.3 Exterior and interior enclosures

3.4 Interior spaces

3.5 Hardware and special equipment

3.6 Plumbing and HVAC equipment

3.7 Equipment and furnishings

3.8 Electrical and communications equipment

4.0 INFORMATION CONCERNING THE CONTEXT OR CONSTRAINTS OF THE BUILDING OR ITS PARTS

4.1 The clients or architects design philosophy

4.2 Budget requirements

4.3 Codes and land use restrictions

4.4 Building standards

4.5 Topography and climate

4.6 Orientation and adjacencies

4.7 Transportation and utilities interface

4.8 Area and regional integration

4.9 Spatial configurations and relationships

4.10 Similar building or parts types critical issues

4.11 Alteration expectancies

4.12 Design and construction scheduling

4.13 Facility operation

Figures 1A to 8A are examples of program information categories commonly found in the literature.

Figure 1A. OPERATION AND BUILDING PROGRAMMING

SOURCE: AIA HANDBOOK OF PROFESSIONAL PRACTICE, CHAPTER 20, 1963.

OPERATIONAL PROGRAMMING

- Functional Requirements
- Space Requirements
- Equipment and Furnishings
- Personnel Requirements
- Financing Requirements
- Organizational Requirements
- Maintenance Requirements

BUILDING PROGRAMMING

- Basic Philosophy
- Site and Climatic Requirements
- Space Requirements and Relationships
- Occupancy Requirements
- Budgeting
- Financing
- Design and Construction Scheduling

Figure 2A. INFORMATION OBJECTIVES OF THE PROGRAM.

SOURCE: HARRIGAN AND WARD

FACILITY DESCRIPTION

- Facility Units
- User Categories
- Furnishing Allocations
- Facility Management Plan
- Alteration Expectancies
- User Activity Descriptions

SOCIOCULTURAL CHARACTER

- Cultural Phenomena
- Social Organization
- Effects of Non-implementation

USER ACTIVITY SUPPORT

- Furnishings and Hardware Design Criteria
- Furnishings, Hardware, and User Placement
- Ambient Environmental Criteria
- Convenience, Safety, and Security

SURFACES

- User Effects Possibilities
- Color, Texture, and Pattern
- Durability and Maintainability

CIRCULATION

Information Flow

User Flow

Equipment and Material Flow

Movement Priorities

Circulation Pattern Summary

SPATIAL CONFIGURATIONS AND ARRANGEMENTS

Space Requirements

Unit Adjacencies

Candidate Spatial Configurations and Arrangements

LOCATION

Area and Regional Integration

Facility Orientations and Adjacencies

Transportation Interface

Figure 3A. ARCHITECTURAL PROGRAMMING.

SOURCE: ARCHITECTURAL LICENSE SEMINARS, 1974.

SITE CONDITIONS

Climate

Topography and Drainage

Geology and Soils

SOCIOLOGICAL ASPECTS OF ARCHITECTURAL PROGRAMMING

Introduction

Territoriality and Dominance

Spatial Considerations

Perception and Cognition

Groups and Roles

ORGANIZATIONAL CONCEPTS

Introduction

Organizational Values

Organization and Design

Organizational Factors

Organizational Patterns

FUNCTIONAL CONSIDERATIONS OF BUILDING TYPES

- Introduction
- Housing
- Schools
- Churches
- Hospitals
- Shopping Centers
- Hotels
- Theaters
- Parking Facilities

PROGRAMMING AND BASIC SPACE DETERMINATIONS

- Introduction
- The Purpose of Programming
- The Programming Process
- Program Instrument
- Determination of Space Needs
- Estimating Space Needs

SCHEDULING OF DESIGN AND CONSTRUCTION

- Design Scheduling
- Construction Scheduling

CODES AND LAND USE RESTRICTIONS

Zoning Ordinances

Building Related Codes

Fire Zones

Occupancy

Types of Construction

Fire Resistance

Fire Safety

Code Requirements

Legal Restrictions on Land Use

BUDGET ANALYSIS AND COST ESTIMATING

Project Budget Analysis

Estimating Construction Costs

Variable Cost Influences

General Office Costs

Project Overhead Costs

Figure 4A. TYPICAL TRADITION ARCHITECTURAL FACT CATEGORIES OF PROGRAMMING DOCUMENTS. SOURCE: WHITE, 1972.

SIMILAR PROJECTS AND CRITICAL ISSUES

CLIENT

FINANACIAL

BUILDING CODES

PLANNING BY RELATED ORGANIZATIONS

FUNCTION

SITE

CLIMATE

GROWTH AND CHANGE

Figure 5A. THE ARCHITECTURAL PROGRAM. SOURCE: MANUAL OF HOSPITAL PLANNING PROCEDURES, 1959.

IDENTIFICATION OF THE PROJECT AND OF THE PLANNING TEAM

A STATEMENT OF THE PURPOSE OF THE PROGRAM

SUMMARY OF THE COMMUNITY NEEDS, THE FUNCTIONAL PROGRAM AND THE LONG-RANGE PLAN

OUTLINE OF THE PROPOSED HOSPITAL ORGANIZATION (IF NOT DETAILED IN THE FUNCTIONAL PROGRAM)

A PROJECT BUDGET, BOTH IN DOLLARS AND IN GROSS FLOOR AREA FOR THE HOSPITAL

STATEMENT OF PLANNING PROCEDURES AND A TENTATIVE TIME SCHEDULE

INFORMATION ON THE BUILDING SITE AND ITS IMPROVEMENTS

GENERAL DESCRIPTION OF THE PROPOSED BUILDINGS

THE DETAILED BUILDING REQUIREMENTS FOR THE HOSPITAL

Inpatient services

Patient units, according to medical specialities, obstetrical an nursery, pediatric, medical, surgical, psychiatric Patient units, according to acuity levels: intensive care, self-help care, chronic care, convalescent care

Outpatient services

Emergency services

Outpatient clinics, according to medical specialities and subspecialities including dental service

Home care and community health programs

Employee health services

Adjunct medical services

Operative treatment: operating, anesthesia, recovery, delivery, labor, cystoscopy shock treatment rooms

Radiological services: x-ray diagnosis and therapy, radioisotopes, teletherapy

Clincial laboratories: pathology, biochemistry, serology, blood bank, basal metabolism, electrocardiography, electroencephalograph, morgue, autopsy

Rehabilitative therapy: physical, occupational, diversional

Paramedical services

Administrative services: administration of all activities, reception and information, admitting, cashier and credit, accounting, purchasing, personnel, public relations

Operational services: communications, receiving and dispatching of supplies, central stores, central sterile supply, laundry, housekeeping, plant engineering and maintenance, plant security

Specialized services; dietary, pharmacy, medical records, library, social services, chaplaincy, personal services as barber and beauty shop

Housing and related facilities not in the main building

Facilities for education and its housing

SPECIFICATION OF MATERIALS

MECHANICAL AND ELECTRICAL REQUIREMENTS

EQUIPMENT REQUIREMENTS

Figure 6A. FUNCTIONAL CONSIDERATIONS. SOURCE: HOSPITAL OUTPATIENT AND EMERGENCY ACTIVITIES

OPERATIONS AND INTERRELATIONSHIPS

LOCATION, COMMUNICATION, AND TRAFFIC

COMPONENTS, CONFIGURATIONS, AND AREA

CONSIDERATIONS

FIXED EQUIPMENT AND MECHANICAL CONSIDERATIONS

ENVIRONMENTAL CONSIDERATIONS

WORKLOAD AND WORKFLOW CONSIDERATIONS

STAFFING CONSIDERATIONS

Figure 7A. MAIN DETERMINANTS OF THE SIZE AND CHARACTER OF PHYSICAL FACILITIES. SOURCE: WHEELER, 1964

HOSPITAL BEDS

OPERATING SUITE

DELIVERY SUITE

EMERGENCY SUITE

ADJUNCT DIAGNOSTIC AND TREATMENT FACILITIES

THE SERVICES DEPARTMENTS

ADMINISTRATION

AMBULANT PATIENT SERVICES

HOUSING FOR STAFF

OTHER SPECIAL SERVICES

ESTIMATED PERSONNEL

SPECIAL EQUIPMENT

SITE REQUIREMENTS

Figure 8A. PLANNING PROCESS CHECKLIST.

SOURCE: ALLEN AND KAROLYI, 1976.

PREPLANNING SCHEDULE

DETERMINATION OF COMMUNITY NEED FOR HEALTH CARE

EVALUATION OF EXISTING CONDITIONS (INCLUDING SEISMIC HAZARDS AND OTHER POSSIBLE CONSTRAINTS).

DEMOGRAPHIC SURVEY OF SERVICE AREA.

STATEMENT OF GOALS AND OBJECTIVES RELATED TO COMMUNITY NEEDS.

CAPITAL FINANCING PLAN.

OPERATIONAL PROGRAM TO MEET GOALS AND OBJECTIVES.

MASTER DEVELOPMENT PLAN AS A FRAMEWORK, INCLUDING GROSS DEPARTMENTAL AREA ALLOCATIONS, SCHEMATIC PLANS, AND CONSTRUCTION STAGING.

COST ANALYSIS.

DETAILED SPACE PROGRAM OF FIRST STAGE FOR CONSTRUCTION.

EQUIPMENT LIST.

DESIGN OF FIRST STAGE.

CONSTRUCTION OF FIRST STAGE.

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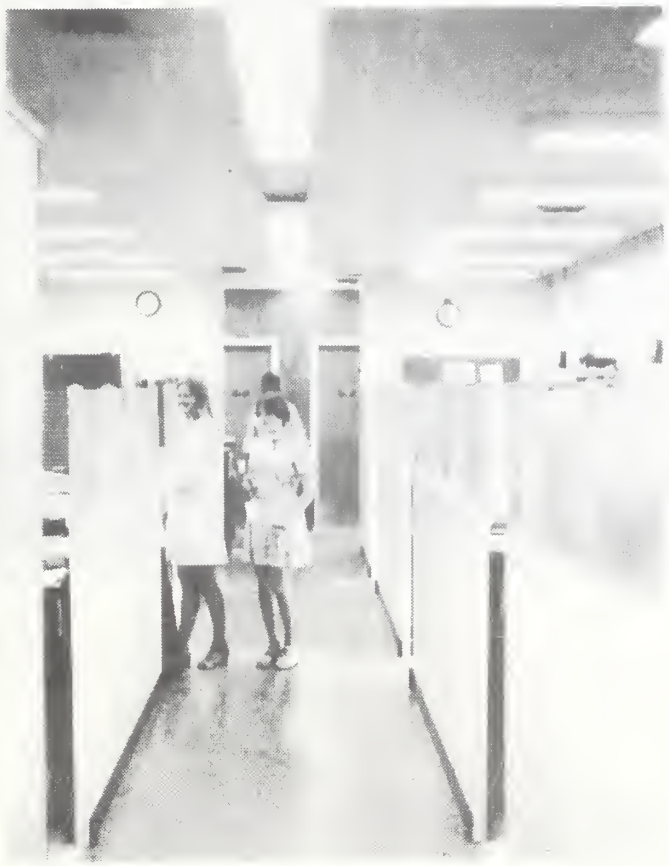
APPENDIX B

Photo Inventory of Building 41

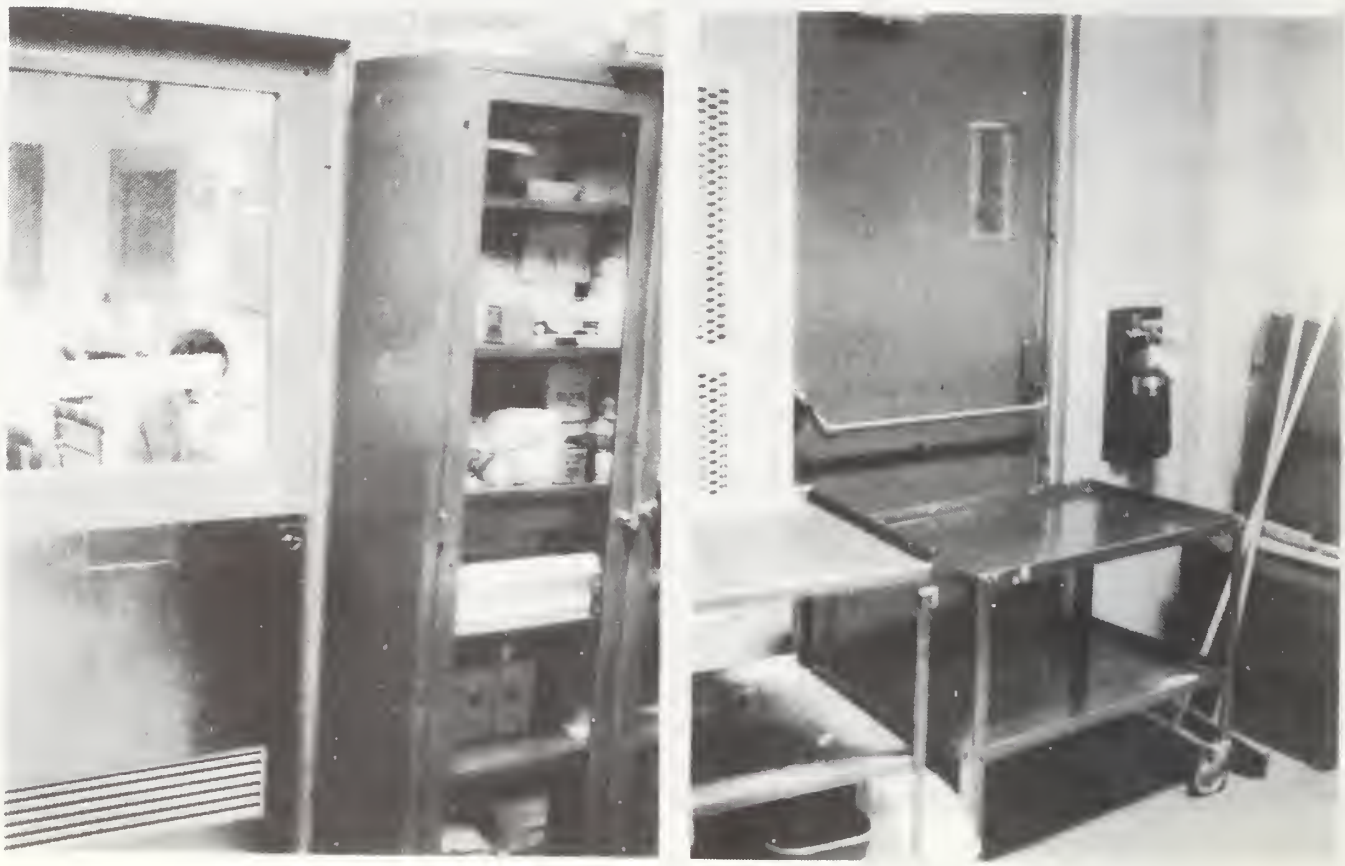
Building 41 faces a large grass covered lawn where a street had originally been intended.



Directly inside the main entrance is a small administrative area with clerical cubicles and private offices off of both sides of a corridor.

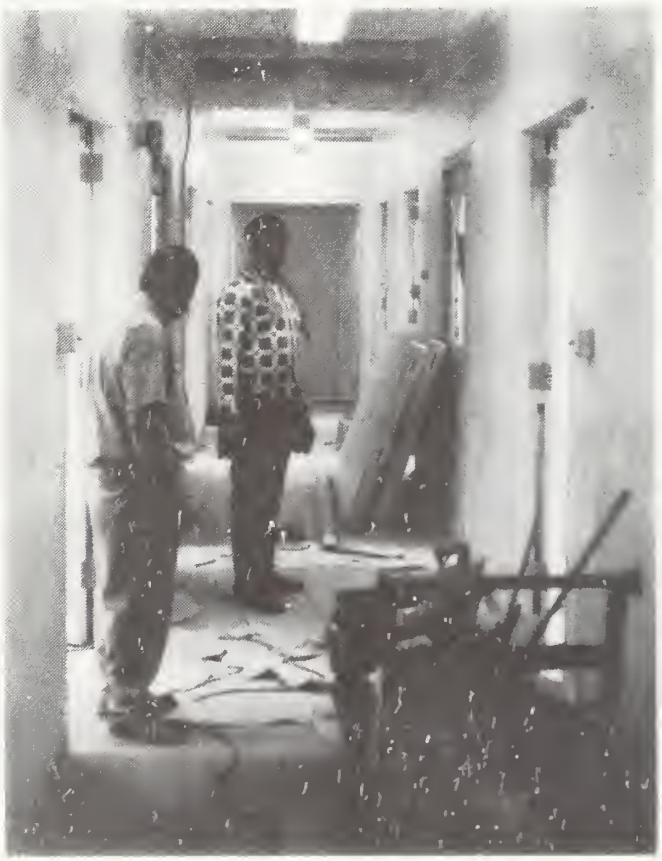
Long corridors separate the laboratory suites and ring the perimenter of the building.

Many corridors have become depositories for equipment.



Corridors and niches within the laboratory suites are used for equipment storage.

Laboratory spaces have an abundance of material and apparatus.



In response to space needs, new laboratory spaces are being added.

The building mechanical space is almost the size of one story of habitable space.

Because of biohazards, light fixtures in the laboratories must be serviced from the mechanical space above.

The waste treatment system remains current with those being installed in new research labs.

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The National Cancer Institute's Emergency Virus Isolation Facility is a laboratory building designed to provide an experimental research environment for all levels of hazardous work related to virus-cancer research. This report represents an attempt to develop a generalizable model for building evaluation through the analysis of the pre-design programming process and the post-construction operation management of the facility.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Architectural analysis; Architectural evaluation; Architectural process; Architectural research; Building evaluation; Building research; Man and environment relations; Post-construction evaluation; People and buildings

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